ASYMMETRIC PRODUCT WITH LINKED BIDS FOR THE SWEDISH BALANCING MARKET? CASE STUDY FROM A HYDRO-DOMINATED MARKET

Ksenia Poplavskaya, AIT Austrian Institute of Technology, ksenia.poplavskaya@ait.ac.at
Stefan Strömer, AIT Austrian Institute of Technology, stefan.stroemer@ait.ac.at
Johann Mayr, AIT Austrian Institute of Technology, johann.mayr@ait.ac.at
Niclas Damsgaard, Svenska kraftnät, Niclas.Damsgaard@svk.se

Overview

Up to date, almost all balancing in Sweden has been provided by large reservoir hydropower plants. In the Swedish market for frequency containment reserve (FCR-N[1]) balancing service providers (BSPs) must reserve capacity symmetrically, i.e. the same amount for both upward and downward regulation. One option to allow more participants and technologies into a rather concentrated FCR-N market would be to allow BSPs to submit asymmetric bids, that is, to determine themselves whether or how much to bid in each direction. Asymmetric bidding could be supplemented by an option to link the bids[2] in the opposing directions, for instance, in order to ensure the plannability of the incumbent hydro-based BSPs' resources.

The authors simulate the Swedish FCR-N market with and without new participating technologies and evaluate the economic effects of 1) switching to an asymmetric product and 2) allowing linked bids for upward and downward regulation. In particular, we evaluate market robustness against non-competitive strategic behavior under the two market designs.

Methods

To answer the research questions, we build two interlinked simulation models:

1) a technical hydro simulation model, which determines the available amount of flexible capacity of reservoir hydropower plants that can be bid in the FCR-N market based on the plants' technical parameters, current value of water as well as fluctuations in inflows and reservoir levels;
2) an agent-based model of the FCR-N market, in which agents with portfolios of three technologies, hydro, wind generation and battery storage can participate. To model possible strategic bidding and its impact on market results, we use a self-developed reinforcement learning algorithm (fitted Q-iteration), which can be assigned to individual agents. An important feature of the algorithm is that a learning agent places bids separately for upward (+FCR-N) and for downward (-FCR-N) regulation but profits in the two markets are optimized jointly. This allows agents to optimally distribute their flexible volume between the two directions.

The overview of the two models is presented in Figure 1.

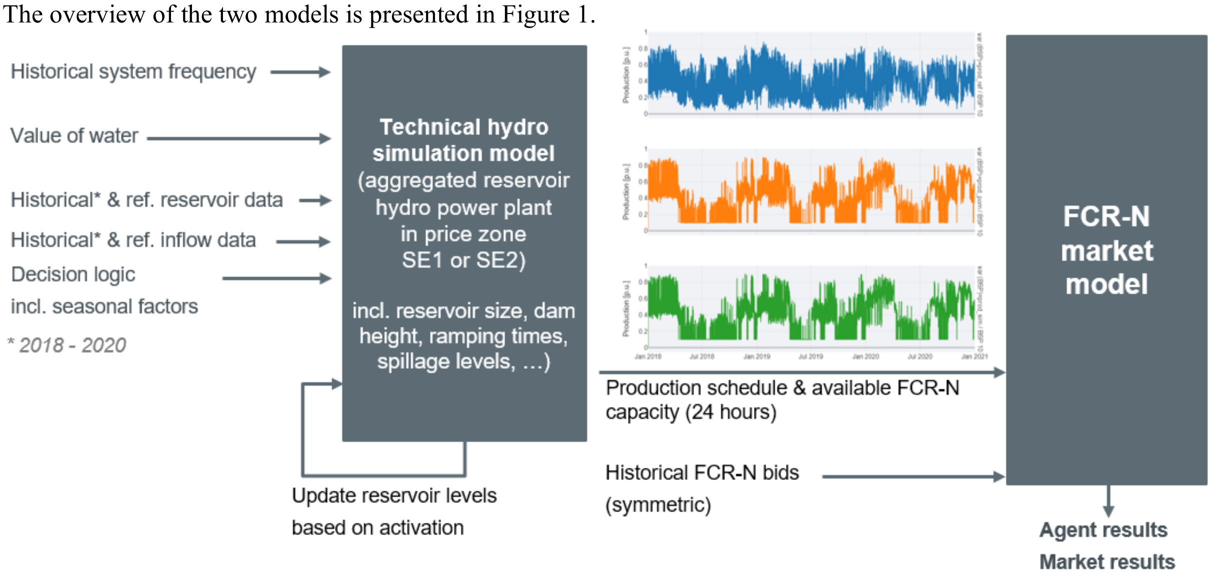

Figure 1. Flow diagram of the method used for this study.

[1] ‚N' stands for normal operation
[2] Bid linking describes the willingness of a BSP to either have the bids in both directions accepted by the TSO or none of them.

Results

The impact of the market design change was analyzed along three different planes, 1) the switch from an symmetric to an asymmetric FCR-N product with or without bid linking, 2) the presence of new market entrants with portfolios of wind generation and battery storage, 3) the possibility for agents to deviate from their true costs and thus bid strategically to maximize profits.

Simulation results show that if only incumbent hydro-based BSPs participate in the market and bid their actual costs, the costs of procurement of FCR-N in an asymmetric market decrease by 10% as compared to a symmetric one. If in addition new market entrants operating wind and battery storage assets are introduced in the market, the cost savings reach 20%. In particular, added wind generation allows to significantly lower the price of downward FCR-N.

Bid linking leads to a less efficient market outcome in all scenarios, as compared to an asymmetric market, in which no bid linking is allowed, and increases the overall procurement costs by about 20%. Specifically, all BSPs linking their upward and downward bids lead to many uneconomic +FCR-N bids that the TSO must award in order to obtain the needed amount of flexibility in the -FCR-N market. This means that bid linking creates less freedom for the TSO to select the most cost-efficient bids in both market segments.

Investigating the impact of strategic bidding under different market designs, we find that, if a single agent behaves strategically and no new entrants are present, both a symmetric market and two separate auctions for +FCR-N and –FCR-N lead to similar price ranges, with spikes up to 450 €/MW. However, a closer look at the price development of the whole simulation year shows periods of improved market performance in the asymmetric market with most price spikes smoothed out and generally lower prices in fall. In a scenario, where all incumbent hydro-based agents can bid strategically, extreme price spikes of over 1800€/MW in a symmetric market are observed although these are significantly lower in an asymmetric market (800-1000€/MW). It is important to note though that, in the latter, agents may freely decide on the allocation of capacity between upward and downward regulation. If agents act in a profit-maximizing manner, we observe instances of shifting volumes from +FCR-N to -FCR-N, which in the worst case can generate a scarcity of supply of approx. 2% for +FCR-N and approx. 1% for -FCR-N over a year.

Strategic agents withdrawing volume from the +FCR-N market to drive up prices still creates – albeit lower – price spikes if new agents and technologies participate in the market. In terms of bid prices, however, strategic agents on average tend to bid closer to their true costs in the scenarios with asymmetric bidding (Figure 2). Same is true if we compare scenarios with and without new market entrants. In almost all scenarios with an asymmetric FCR-N product, agents' profits decline whereas most scenarios with asymmetric bidding lead to a net welfare gain.

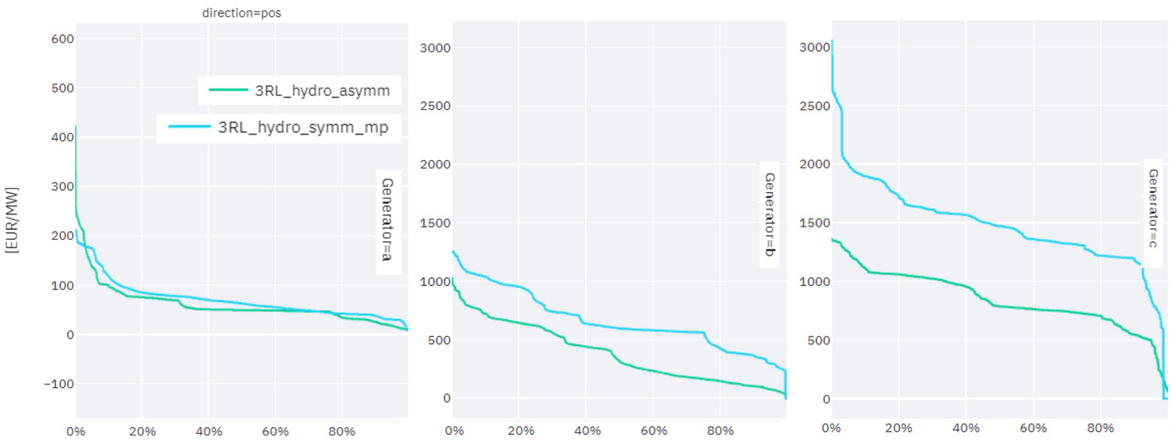

Figure 2. Bid price duration curve of agent#1 and its three generators, a, b and c, in a symmetric (in blue) and an asymmetric (in green) market.

Conclusions

In this study, we show that, in most scenarios, a switch to an asymmetric market resulted in a decrease of FCR-N procurement costs of approx. 10%. However, if all agents linked their +FCR-N and –FCR-N bids, this increased system costs by over 20% and marginal price volatility. Allowing new entrants and technologies into the market resulted in an improvement of all studied indicators, with system costs lower than in incumbent-only scenarios. The market efficiency deteriorated as a result of strategic behavior, which manifests itself not only in non-competitive bid prices but also in some agents shifting some flexible volume from the +FCR-N to the -FCR-N market, thus reducing available supply in the former. Nevertheless, strategic bidders tended to bid closer to their true costs in asymmetric scenarios.